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A REEVALUATION OF THE OZARK ENDEMIC *CLAYTONIA OZARKENSIS* (MONTIACEAE)

GEORGE YATSKIEVYCH
Missouri Botanical Garden
P.O. Box 299
St. Louis, Missouri 63166
george.yatskievych@mobot.org

RANDALL J. EVANS
Missouri Department of Conservation
551 Joe Jones Blvd.
West Plains, Missouri 65775
randy.evans@mdc.mo.gov

C. THEO WITSELL
Arkansas Natural Heritage Commission
1500 Tower Building, 323 Center St.
Little Rock, Arkansas 72201
theo@arkansasheritage.org

ABSTRACT

Claytonia ozarkensis was described in 2006 as a near-endemic to the Ozarks, based on a small number of specimens from Arkansas, Missouri, and Oklahoma. Field work at voucher sites in Missouri and Oklahoma failed to relocate populations, which led to more detailed morphological study of specimens purporting to document the species. Several of these specimens, including the type of *C. ozarkensis*, were redetermined as a broad-leaved form of the widespread *C. virginica*. The remaining specimens continue to represent a novel taxon, which is described here as **Claytonia arkansana** Yatsk., R. Evans, & Witsell, **sp. nov**. The range of *C. arkansana* is even more restricted than originally believed, and the documented distribution of the taxon is limited to just three counties in the Ozark region of Arkansas.

KEY WORDS: Arkansas flora, Ozark endemics, *Claytonia*, Montiaceae

The genus *Claytonia* L. (Montiaceae) comprises some 27 species distributed in temperate North America and eastern Asia. Among these, the group of ca. nine tuberous species of Spring Beauties has been especially contentious taxonomically, in part because the plants are character-poor morphologically, having relatively simple and similar vegetative architecture and strong similarities in floral morphology. The taxa thus are relatively cryptic, and botanists have tended to rely heavily on distributional data to aid in specimen determinations. Additionally, some of the species are prone to high rates of polyploidy and aneuploidy, with the widespread *C. virginica* L. of the eastern USA and adjacent Canada exhibiting the longest aneuploid series on record ($2n$ = 12 to ca. 190; Rothwell & Kump 1965). Morphological extremes in leaf width have been suggested to be correlated with differences in chromosome number in this species (Lewis et al. 1967).

The most recent taxonomic revision of the genus was that of Miller and Chambers (2006), who performed field, greenhouse, and herbarium studies to complete a detailed analysis of macro- and micro-morphological characters and also summarized cytological, phytochemical, and biogeographic data on the group to justify species circumscriptions and a new classification of the taxa. Miller and Chambers relied on a variety of floral and vegetative characters to distinguish taxa but continued to emphasize differences in geographic distributions to distinguish among species, especially in the group of morphologically similar Spring Beauties related to *Claytonia virginica*.

Claytonia virginica is among the most widespread species of Spring Beauties and is distributed throughout the eastern half of the USA west to Minnesota, southeastern Nebraska, and eastern Kansas, Oklahoma, and Texas, as well as portions of Ontario and Quebec (Miller & Chambers 2006). Variations in characters ranging from leaf width to corolla color have resulted in the description of a number of infraspecific taxa, most of which have not been evaluated critically other than by examination of suites of herbarium specimens. In the region of the Ozark Uplift, which occupies large portions of Missouri and Arkansas, as well as a small adjacent area in northeastern Oklahoma and plausibly a tiny portion of adjacent southern Illinois, *C. virginica* is the common Spring Beauty reported in floristic accounts. It is the sole Spring Beauty reported for Oklahoma (Waterfall 1969; Tyrl et al. 2009) and is the only taxon included in most of the floristic literature for Illinois (Mohlenbrock 2002). However, Jones and Fuller (1955) noted that a series of earlier reports of *C. caroliniana* Michx. for Illinois, including mention in *Gray's Manual of Botany* (Fernald 1950), were based on a misinterpretation of that taxon by some authors and instead should be included in *C. virginica*.

Claytonia virginica was the only species in the genus included in Steyermark's (1963) *Flora of Missouri*, but that author noted scattered occurrences of plants with elliptic to lanceolate leaves 10–33 mm wide, which he assigned to f. *robusta* (Somes) E.J. Palmer & Steyerm. Only in the literature on Arkansas has more than one species been accepted to occur in the state (Smith 1994; Arkansas Vascular Flora Committee 2006), with *C. virginica* widespread and *C. caroliniana* mapped from four counties in the northcentral and northwestern portions of the state (Smith 1988).

In their taxonomic revision of the genus, Miller and Chambers (2006) added a new species to the central USA, which they named *Claytonia ozarkensis* J.M. Mill. & K.M. Chambers. Their new taxon was reported to be endemic to the Ozark region of Arkansas and Missouri plus the Ouachitas of eastern Oklahoma, with nine total localities in three counties in Missouri, three counties in Arkansas, and two somewhat disjunct counties in eastern Oklahoma. *Claytonia ozarkensis* was stated to be related to a small cadre of relatively broad-leaved tuberous species, including *C. caroliniana*. Miller and Chambers restricted the distribution of the latter taxon to a broad region in the eastern USA and Canada, no closer to the Ozarks than central Kentucky and Tennessee, and in effect redetermined as *C. ozarkensis* the Arkansas specimens reported earlier under the name *C. caroliniana*.

The new taxon described by Miller and Chambers (2006) was stated by them to differ from *Claytonia caroliniana* in its tendency for young plants to produce rhizomes (in addition to tubers) and its multibracteate inflorescences (vs. only the lowermost 1 or rarely 2 flowers bracteate). Although Miller and Chambers did not specifically discuss the relationship between *C. ozarkensis* and *C. virginica*, it is evident from their descriptions that they thought *C. virginica* to differ from *C. ozarkensis* in its generally narrower leaf blades, unibracteate inflorescences, and sessile cauline leaves.

The description of *Claytonia ozarkensis*, which Miller and Chambers (2006) remarked might be worthy of protection under the federal Endangered Species Act, created strong interest among botanists and conservationists in Arkansas, Missouri, and Oklahoma to determine the modern-day status of this recently segregated taxon. However, not all of the herbarium specimens cited had sufficiently detailed label data to permit attempts to relocate populations, including specimens collected in Jefferson County, Missouri, and Sequoyah County, Oklahoma. A survey in 2008 by staff of the Oklahoma Natural Heritage Program at the collection site for the Pittsburg County, Oklahoma, specimen failed to yield any plants (Bruce Hoagland, pers. comm.). Additionally, searches during several field seasons by a number of Missouri botanists failed to locate plants at the stations reported for Ozark and Stone counties in Missouri. Only in Arkansas were inventory efforts for *C. ozarkensis* successful. These inventories documented the existence of large, healthy populations in Cleburne and Faulkner Counties and allowed more detailed field and herbarium studies to be conducted.

Based on plants gowing in Arkansas, *Claytonia ozarkensis* is a rock crevice specialist of sandstone bluffs and bluff tops (Fig. 1). It does well in both full sun and moderate shade at sites that become seasonally dry as well as sites with more permanent seepage and is restricted to places where layering and weathering of the substrate has created more or less horizontal ledges and deeply incised rock seams. Plants flower relatively early in the growing season, most frequently from late February to early April, and fruits mature relatively rapidly after flowering. Albrecht and Penagos Z. (2012), who studied the seed germination ecology of *C. ozarkensis*, collected mature seed samples on 22 April 2009. Their study indicated that the seeds germinate readily at low temperatures and in the dark. From this, they concluded that although *C. ozarkensis* disperses copious quantities of seeds, these tend to germinate in dark crevices in late fall to early winter as temperatures decline and thus do not tend to persist long-term in the soil as a seed bank. It was also noted that *C. ozarkensis* disperses its seeds directly into suitable habitat, for the inflorescences recurve as the fruits mature, directing the mature capsules back toward the rock crevices adjacent to the parental plant (Albrecht & Penagos Z. 2012; Matthew Albrecht, pers. comm.).

In nature and on herbarium specimens, plants of *Claytonia ozarkensis* are relatively distinctive morphologically. Because young plants often are not collected, the tendency to form slender rhizomes is usually not observed on herbarium material, but it can be especially evident along bluff tops where loose shelf rocks can be temporarily pried back to reveal intact below-ground structures of the plants. The basal leaves in mature *C. ozarkensis* are long-petiolate, with well differentiated blades. The cauline leaves also are noticeably petiolate and have well differentiated blades; in this feature they differ consistently from broad-leaved individuals of *C. virginica*, in which the leaves taper to a base that is sessile or nearly so. Except in very depauperate inflorescences, bracts are present at three or more nodes (vs. usually unibracteate in *C. carolinana* and *C. virginica*). The inflorescence axis in *C. ozarkensis* is slender and the pedicels are filiform and continue to elongate noticeably after flowering as the capsules mature. The leaves of *C. ozarkensis* also are relatively thin and lacking in structural support, which is reflected in herbarium specimens by the leaves becoming matted and/or torn during the mounting process and so thin as to be nearly translucent.

In addition to morphological considerations, the species occupy different habitats. At all of the extant sites, plants of *Claytonia ozarkensis* are restricted to sandstone ledges and adjacent edges of bluff tops (Fig. 1). Even where *C. virginica* occurs in proximity to *C. ozarkensis*, plants of the latter are invariably in more terrestrial, rather than cliffy, habitats. *Claytonia caroliniana* is strongly allopatric to *C. ozarkensis* and also usually occurs in terrestrial habitats. Genetically, the three taxa also appear distinct. In a preliminary study of molecular-genetic variation, Croft et al. (2011 and in prep.) were able to distinguish Arkansas samples of *C. ozarkensis* from plants of the other two taxa.

In searching for plants of *Claytonia ozarkensis* at the Ozark and Stone county localities in Missouri, both of which have voucher specimens with relatively precise locality data, we were surprised to find the habitat and substrate very different from those at the extant sites in Arkansas. At the Stone County locality, the impoundment of the White River to create Table Rock Lake flooded a lot of potential habitat, but bluffs remain in the area near the former Cole Ford where the voucher (*Steyermark 67475*, F) was collected on 30 April 1947 (specimen image: <http://www.tropicos.org/Image/100165890>). At this location and in surrounding areas, the cliffs are entirely of dolomite. Despite their proximity to the water of the reservoir, the cliffs are dry and exposed, and there is no significant seepage in the area.

The Ozark County locality also differs markedly from those in Arkansas. At this station, there occurs a steep, wooded slope with scattered small dolomite outcrops, which lack the pronounced seams and ledges that the species prefers. Miller and Chambers (2006) noted that in addition to the *Claytonia ozarkensis* specimen (*Steyermark 4725*, MO; Fig. 4), they also examined a specimen of typical *C. virginica* collected on the same date and at the same locality (*Steyermark 4715*, MO) and used this as

evidence that the two species could grow in proximity. During our searches at the site, we found abundant narrow-leaved *C. virginica* and scattered individuals with broader leaves referable to *C. virginica* f. *robusta*, but no plants referable to *C. ozarkensis*.

Our inability to locate plants of *Claytonia ozarkensis* or even habitat suitable for the species at the historical Missouri stations caused us to reexamine the voucher specimens cited by Miller and Chambers (2006), using the characters described above. We were surprised to find that both of the two specimens collected in Oklahoma (Pittsburg Co., *Cutler 3225*, MO; Sequoyah Co., *Stephen 90362*, KANU) instead represent plants of *C. virginica* with relatively broad leaves. In both of these specimens, the cauline leaves are essentially sessile and the inflorescences are unibracteate. For the Sequoyah County voucher, which comprises eight plants, these discrepancies had already been annotated on the sheet itself by the late Ron McGregor at some point after the formal description of *C. ozarkensis* in 2006.

Arkansas-collected specimens studied from Cleburne, Faulkner, and Van Buren counties all appear to be correctly determined as *Claytonia ozarkensis*. However, the Washington County, Arkansas, voucher (*Hite 55-47*, UARK) and all three of the Missouri vouchers (Jefferson Co., *Hasse s.n.* in May 1887, MIN; Ozark Co., *Steyermark 4725,* MO; Stone Co., *Steyermark 67475*, F), when examined carefully, prove to be merely broad-leaved variants of *C. virginica*. Thus, based on presently available evidence, the taxon that Miller and Chambers (2006) described as *C. ozarkensis* appears not only to be restricted to the Interior Highlands but is even more narrowly endemic to a relatively small portion of the Boston Mountains and Arkansas Valley (Level III) Ecoregions of Arkansas (Woods et al. 2004; Fig. 3). More specifically, all known sites are restricted to the Lower Boston Mountains and Arkansas Valley Hills (Level IV) Ecoregions (Woods et al. 2004). Future inventory efforts may yet add localities from adjacent states, but, thus far, diligent field work by a number of experienced botanists has failed to turn up localities for this taxon in Missouri, Oklahoma, or elsewhere in Arkansas. Additionally, although Miller and Chambers listed the habitats as "On moist sandstone bluffs and wooded hilltops, at moist microsites near springs or seeps on limestone," it now appears that *C. ozarkensis* does not occur on calcareous substrates or wooded hilltops but instead has a narrow ecological niche involving sandstone crevices and ledges of bluffs and bluff tops. More specifically, all known sites occur on outcroppings of the Atoka Formation and Hale Formation (Haley et al. 1976).

The redetermination of the Ozark County, Missouri, specimen as a broad-leaved variant of *Claytonia virginica* has another unfortunate consequence, as this specimen was designated as the type of *C. ozarkensis* by Miller and Chambers (2006). Although their morphological description was relatively accurate in circumscribing a valid taxon, the name *C. ozarkensis* must become a heterotypic synonym of *C. virginica* and a replacement name must be coined for the Arkansas endemic. Here, we propose the following.

Claytonia arkansana Yatsk., R. Evans, & Witsell, **sp. nov. TYPE: USA. Arkansas.** Cleburne Co.: Mossy Bluff Trail at Greer's Ferry Lake, ca. 3.5 air mi E of Heber Springs and ca. 1 mi S of State Highway 25 via road to parking lot, steep NE-facing bluffy slope with sandstone outcrops along trail below stairs from parking area; 35°30'47.8" N lat., 091° 59'56.7" W long.; elevation 600 ft, 23 Mar 2007, *Croft, Witsell, Pelton, & Waselkov 003* (holotype: MO-5954145). — Arkansas Spring Beauty (Figs. 1, 2, 3).

Differing from *Claytonia caroliniana* and *C. virginica* in its multibracteate inflorescences and long-petiolate basal and cauline leaves, which are well differentiated into petiole and lamina.

Plants ephemeral, perennial herbs, glabrous; tubers 6–15(–20) mm in diameter, ± globose to boradly ovoid, periderm dark brown, appearing very finely horizontally striate under magnification, when young tapered abruptly to a slender taproot, but frequently with only a mass of fine, white adventitious roots at maturity; young tubers occasionally also producing slender white rhizomes; aboveground

structures produced from a cluster of diaphanous apical scales, these 0.8–2.0 mm long, ovate. **Stems** 1 to more commonly several, 4–15 cm long at flowering (measured from base to inflorescence tip), continuing to elongate somewhat as fruits mature, unbranched, mostly arched or spreading, becoming recurved at fruiting, slender. **Basal leaves** usually several to numerous; petiole 1–12 cm long, slender, dilated apically and basally; lamina 4–15 mm long, linear to narrowly spatulate in seedlings, but in mature plants well differentiated, ovate to somewhat rhombic-ovate, elliptic, or broadly elliptic, rounded to very blunt at the tip, short-tapered at the base, thin-textured (often drying translucent), margins entire. **Cauline leaves** opposite, 1 pair; petiole (0.7–)1.5–8.0 cm long usually slender, dilated apically; lamina (4–)10–26 mm long, (3–)6–12 mm wide, ovate to bluntly rhombic, elliptic, or occasionally elliptic-obovate, sometimes slightly asymmetrically so, rounded or very blunt at the tip, short-tapered at the base, thin-textured (often drying translucent), margins entire. **Inflorescences** monochasial, appearing loosely clustered at start of anthesis, soon becoming racemiform, the nodes mostly well-spaced, multibracteate, the bracts green to white, alternate at most nodes or sometimes the lowermost positioned below nodes, 0.8–3.0 mm long, elliptic to ovate or nearly circular, rounded to sharply pointed at the tip, cuneate to rounded basally, the largest occasionally broadly rounded and somewhat circling the axis. **Flowers** (2–)6–14 per inflorescence; pedicel 12–48 mm long at anthesis, continuing to elongate as fruits mature, filiform, straight to somewhat arcuate, becoming more strongly curved after flowering. **Calyces** 2.5–4.5 mm long at anthesis, elongating to 3.5–5.5(–7.0) mm at fruiting, ± campanulate. Sepals 2, persistent, broadly ovate to broadly obovate, broadly rounded to nearly truncate apically, occasionally bluntly apiculate, the bases imbricate. **Corollas** 10–16 mm in diameter, the petals spreading; petals 5, 6–12 mm long, obovate-spatulate, white or less commonly pinkish-tinged distally, the veins often pink, fading uniformly light pink. **Fruits** capsules, 2.5–4.0 mm long, ovoid, bluntly pointed at the tip, unilocular, with 1–6 seeds (placentation basal), dehiscence longitudinal along the 3 septa. **Seeds** 1–3 mm in longest dimension, flattened, broadly reniform to nearly circular, the rim rounded, the surface black, smooth, and shiny; elaiosome 0.8–2.0 mm long, white. $2n = 8II$ (as *C. caroliniana*; Doyle et al., 1984). Flowering late February to early April, fruiting late March to late April.

Distribution and habitat. Endemic to the Ozarks and Arkansas Valley portions of Arkansas (Fig. 3), at 135–275 m elevation. Tops and faces of sandstone cliffs, where rooting in crevices of ledges and horizontal seams, in areas with at least seasonal seepage, in full sun to moderately dense shade.

Additional specimens examined. USA. Arkansas. Cleburne Co.: S side of State Highway 25, S of Greers Ferry Dam, ca. 3 air mi E of Heber Springs, Mossy Bluff Trail, E-facing sandstone bluffs, 23 Mar 2007, *Witsell, Croft, Pelton, & Waselkov 07-07* (MO); same locality, 19 Apr 2007, *McKenzie & Witsell 2258* (MO); same locality, 4 Apr 2008, *Yatskievych 08-03* (MO); Quitman, ca. 4 mi E of junction with State Hwy 16 on Diamond Bluff Road, ca. 4 air mi S of Higden. gladey top of tall N-facing sandstone bluff overlooking Greers Ferry Lake, 23 Mar 2007, *Croft, Witsell, Pelton, & Waselkov 004* (MO); same locality, 4 Apr 2008, *Yatskievych 08-08* (MO); S side of Heber Springs, Bridal Veil Road, ca. 0.4 mi W of junction with State Hwy 25, mostly N-facing sandstone bluffs beginning above falls and continuing downstream, 4 Apr 2008, *Yatskievych 08-09* (MO). Faulkner Co.: 7 mi N of Wooster, in rocky crevices on steep sandstone bluffs above Cove Creek, 22 Mar 1973, *Lewis 7878* (MO); sandstone bluff above cove Creek, 15 mi N of Conway, 2 Apr 1956, *Moore 56,28* (UARK); NE-facing sandstone bluffs above North Fork of the Chadron River, ca. 4 mi N of Greenbrier, abundant in crevices of shaded sandstone bluffs, 18 Apr 1969, *Redfearn & Redfearn 25881* (SMS). Van Buren Co.: Abundant on N-facing moist sandstone bluffs, ca. 1/2 mi NE of Gravesville, on the North Fork of the Cadron, 13 Apr 1978, *Rhinehart 26* (UARK).

Claytonia virginica L., Sp. Pl. 1: 2034. 1753. **LECTOTYPE** (designated by Lewis, Oliver, and Suda, Ann. Missouri Bot. Gard. 54: 168. 1967): *Kalm s.n.* (LINN-285.1).

Claytonia ozarkensis J.M. Mill. & K.L. Chambers, Syst. Bot. Monogr. 78: 75–77, f. 31, 32. 2006 (pro parte, including type). Figure 2.

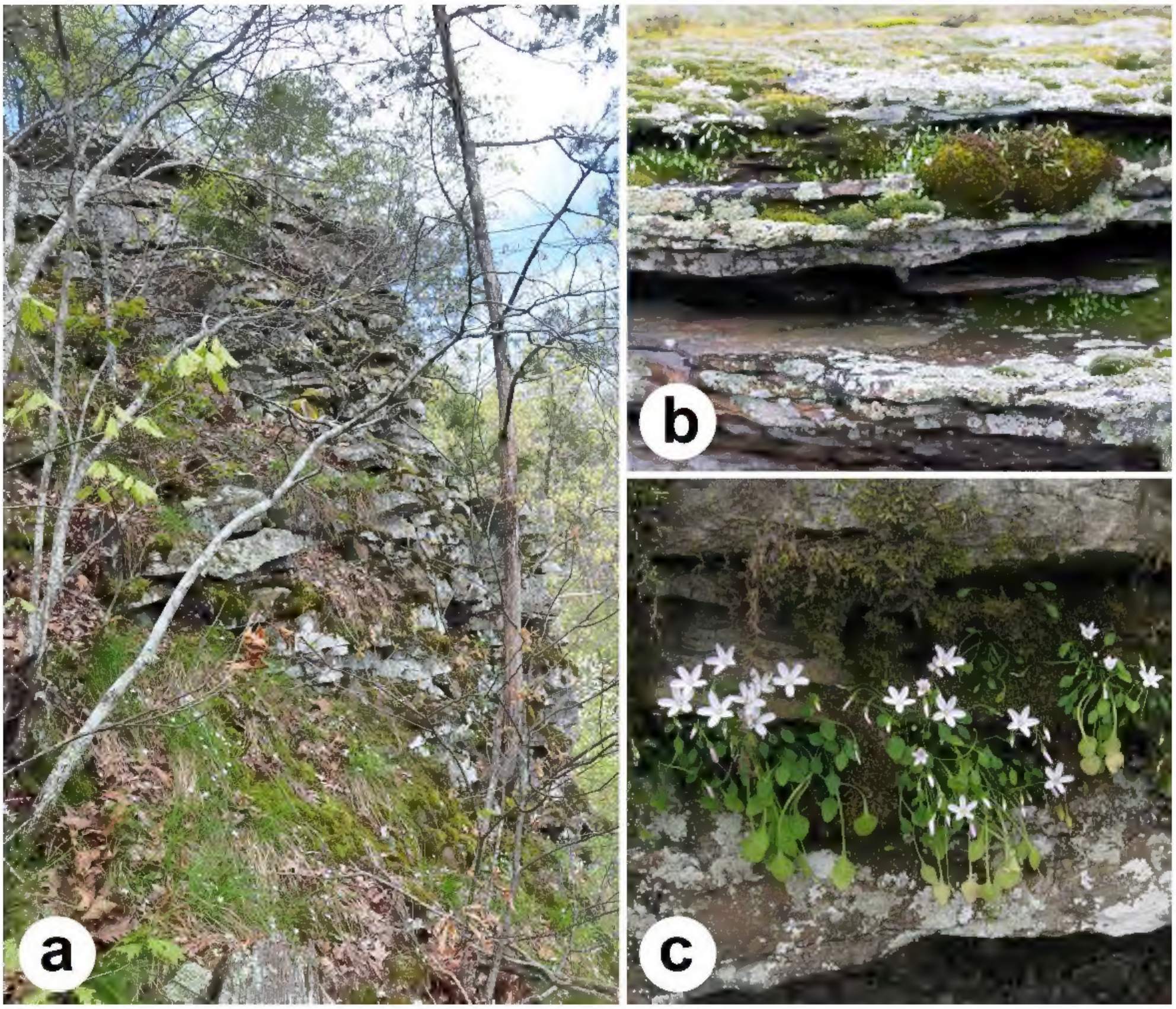

Figure 1. Views of *Claytonia arkansana* in nature. **a)** Typical habitat on sandstone bluffs, Cove Creek Natural Area, Faulkner County, Arkansas. (photo by Brent Baker); **b)** Dense population along sandstone blufftop, private property along Greer's Ferry Lake, Cleburne County, Arkansas (photo by George Yatskievych); **c)** plants on sheltered sandstone ledge, along Mossy Bluff Trail above U.S. Army Corps of Engineers Greer's Ferry Lake, Cleburne County, Arkansas (photo by Genevieve Croft).

In addition to similarities with *Claytonia caroliniana*, Miller and Chambers (2006) discussed the strong morphological similarity of the plants they called *C. ozarkensis* to two western species, *C. ogilviensis* McNeill (of the Yukon) and *C. umbellata* S. Watson (of northern California, Nevada, and Oregon). Both of these rare species share the usually multibracteate inflorescences of *C. arkansana* but differ in their generally larger, more turnip-shaped tubers and pink to magenta corollas. A more thorough analysis of these strongly allopatric taxa is beyond the scope of the present study, but we see no reason to doubt the careful taxonomic analysis of Miller and Chambers.

MISSOURI
BOTANICAL GARDEN
HERBARIUM
Nº 5954145
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PLANTS OF ARKANSAS, U.S.A.
PORTULACACEAE
Claytonia ozarkensis J.M. Miller & K.M. Chambers
CLEBURNE COUNTY: Mossy Bluff Trail at Greer's Ferry Lake, ca. 3.5 air mi E of Heber Springs and ca. 1 mi S of State Highway 25 via road to parking lot; sttep NE-facing bluffy slope with sandstone outcrops along trail below stairs from parking area. Associated Species: *Saxifraga palmeri, Carex albicans, Ranunculus harveyi, Toxicodendron radicans, Polymnia canadensis, Elymus* sp., *Woodsia obtusa*. 35°30'47.8"N Lat., 091° 59'56.7"W Long.; elevation 600 ft.
23 March 2007
Genevieve Croft 003
with Theo Witsell, John Pelton, Katherine Waselkov
MISSOURI BOTANICAL GARDEN HERBARIUM (MO)
Croft et al. 003 (MO)
HOLOTYPE OF:
***Claytonia arkansana* Yatsk., R. Evans & Witsell,**
sp. nov. ined. Phytoneuron 2013-XXX.
MISSOURI BOTANICAL GARDEN HERBARIUM (MO)

Figure 2. Holotype of *Claytonia arkansana* Yatsk., R. Evans & Witsell (*Croft et al. 003*, MO). Note the leaves, which have become relatively thin and translucent upon drying and comprise long, slender petioles and well differentiated blades. Image courtesy of the Missouri Botanical Garden herbarium; for a higher-resolution view, see <http://www.tropicos.org/Image/100216734>.

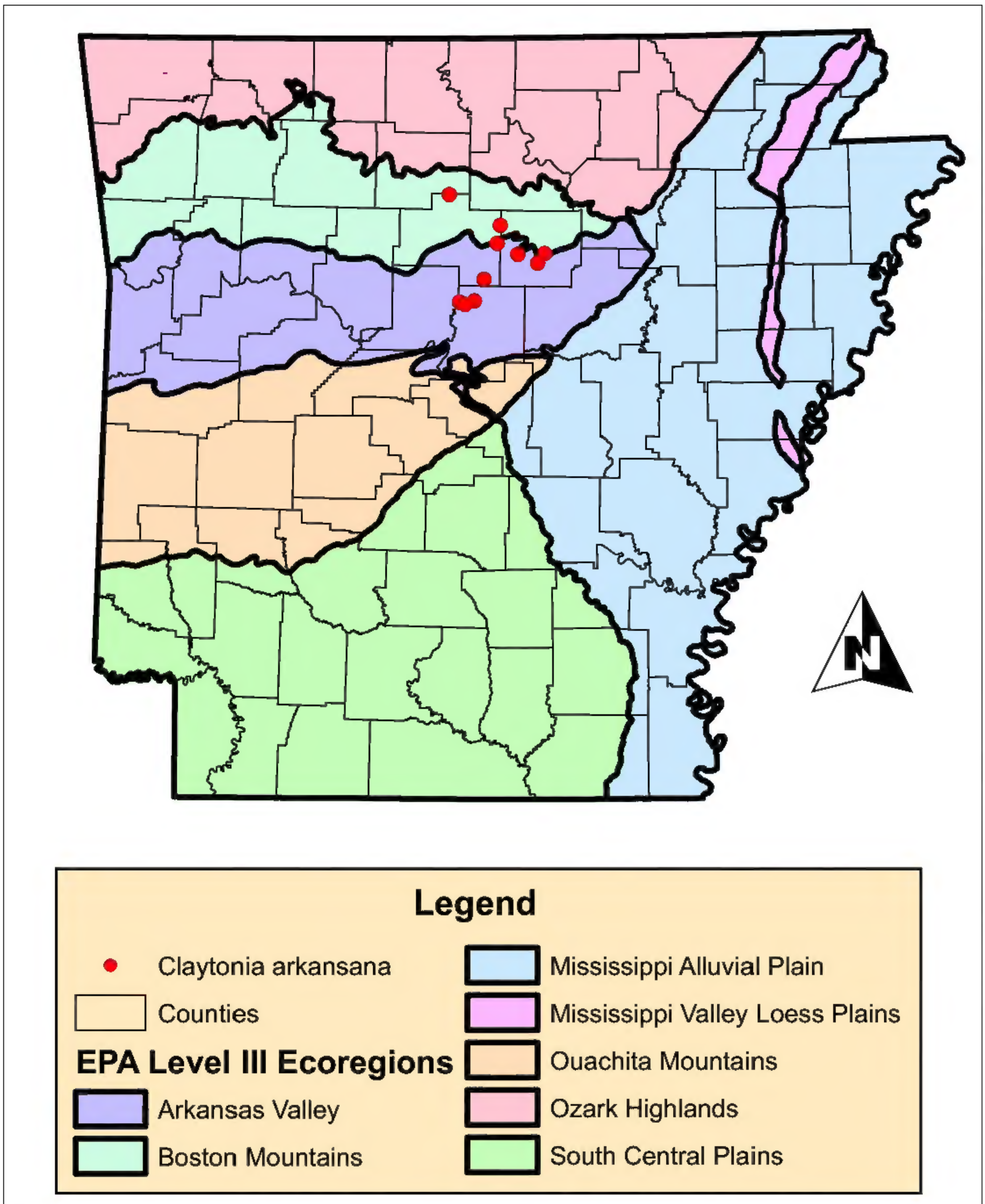

Figure 3. Map showing all known sites of *Claytonia arkansana* (n = 10) over the major (Level III) ecoregions of Arkansas. Base map courtesy of the Arkansas Natural Heritage Commission; for more information on the ecoregions of Arkansas, see Woods et al. (2004).

Figure 4. Holotype of *Claytonia ozarkensis* (*Steyermark 4725*, MO). Note the cauline leaves, whose blades taper to the bases, lacking well differentiated petioles. Image courtesy of the Missouri Botanical Garden herbarium; for a higher-resolution view, see <http://www.tropicos.org/Image/100216735>.

The recircumscription of the Arkansas cliff-dwelling plants as *Claytonia arkansana* does not address all of the taxonomic issues involving the *C. virginica* complex in that state. The Arkansas Natural Heritage Commission currently is tracking another unusual variant that is represented by at least two populations in Pope and Van Buren counties (Fig. 5). Plants at these sites are strongly reminiscent of true *C. caroliniana* in their unibracteate inflorescences and broad leaf blades. They occur as rare individuals in glades and woodland margins, in soils derived from sandstone substrates. The taxonomic status of these anomalous plants requires more detailed study in the future, but they do not fit well morphologically into either *C. arkansana* or *C. virginica*.

Arkansas Natural
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Herbarium (ANHC)
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0 cm 1 2 3 4 5 6 7 8 9 10
Flora of the South Fork Native Plant Preserve
ARKANSAS
Van Buren County
PORTULACACEAE
Claytonia caroliniana Michx.
Carolina spring beauty
Rare in cedar-encroached glade near spring run, on west side of peninsula.
N 35.55960, W 92.38079.
Fresh flowers white to pink with purple veins on petals.
Theo Witsell 05-113
10 April 2005
This specimen serves as a voucher for the Flora of the South Fork Native Plant Preserve, conducted by Theo Witsell and Brent Baker for the Gates Rogers Foundation.

Figure 5. Specimen of anomalous *Claytonia caroliniana*-like plants from a sandstone glade, South Fork Native Plant Preserve, Van Buren County, Arkansas (*Witsell 05-113*, ANHC). Note the unibracteate inflorescence on the left-hand plant. Image courtesy of the Missouri Botanical Garden herbarium; for a higher-resolution view, see <http://www.tropicos.org/Image/100216736>.

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